Hydrological Issues in Regional Climate Modeling of East Asian Summer Monsoon

Bin Wang and Hongwei Yang

International Pacific Research Center,

School of Ocean and Earth Science and Technology, University of Hawaii, Honolulu, HI 96822

Why Concern RCM

- RCM is booming due to enormous demands in regional prediction of future change, downscaling climate predictions, and regional climate applications.
- It is imperative to better understand the strength, deficiencies, and limitations, as well as the sources of uncertainties with RCM simulations.
- A number of RCM intercomparison projects have been carried out to identify the common model strengths and weaknesses over specific regions such as

  Europe (Christensen *et al.* 1997),

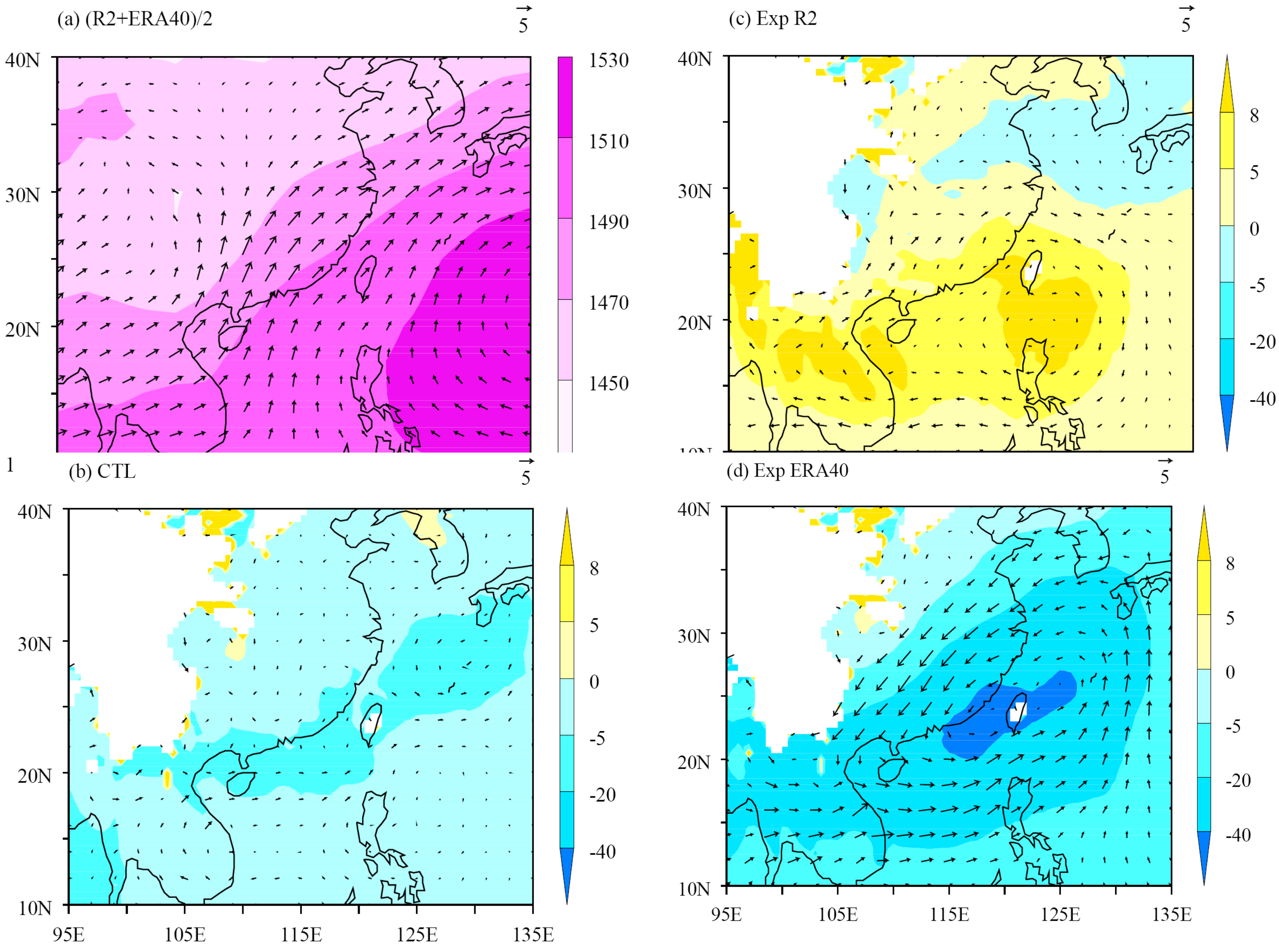
  United States of America (Takle *et al.* 1999, Curry and Lynch 2002, Anderson *et al.* 2003), and

  East Asia (EA) (Leung and Ghan 1999, Fu *et al.* 2005).

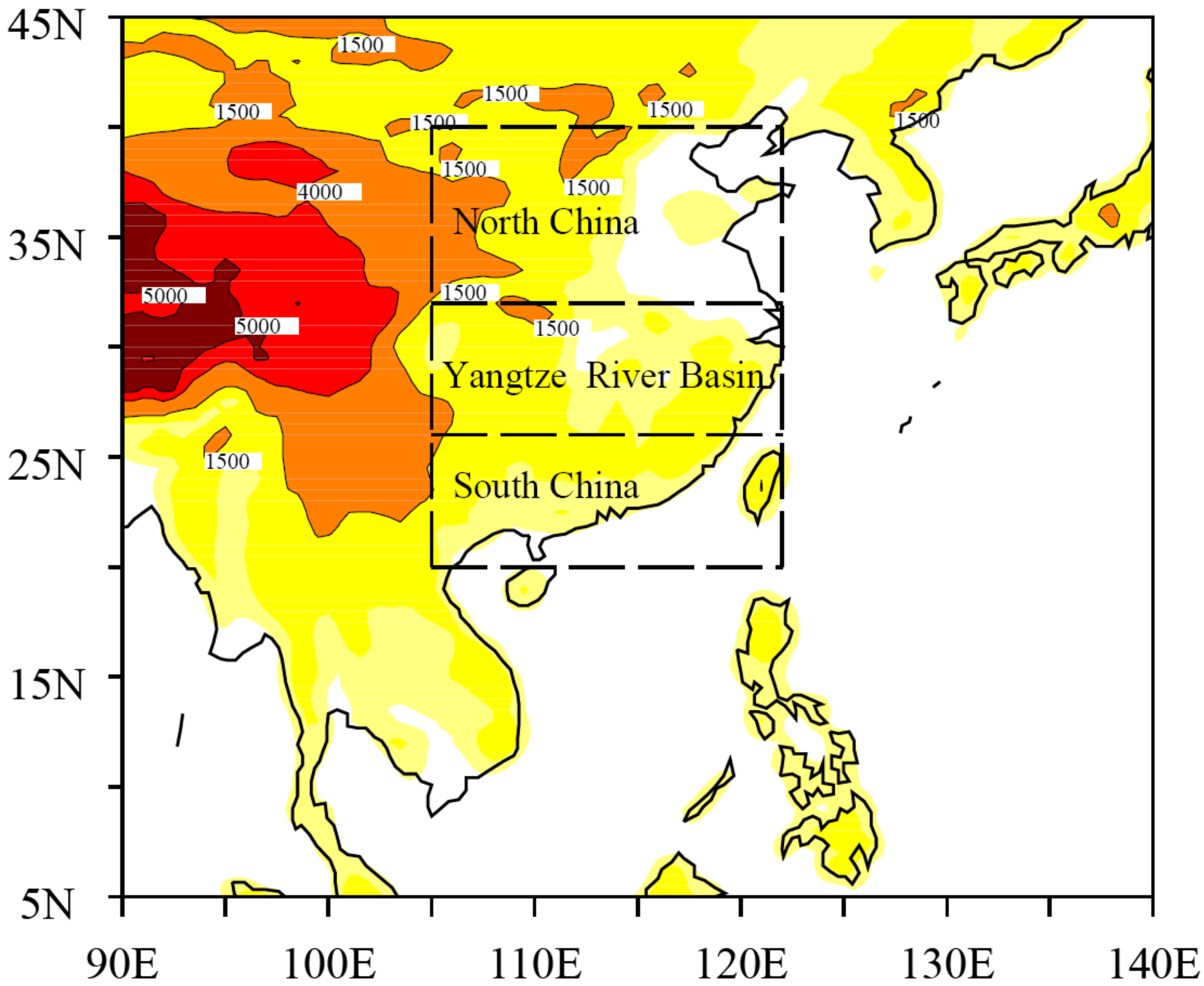
Questions

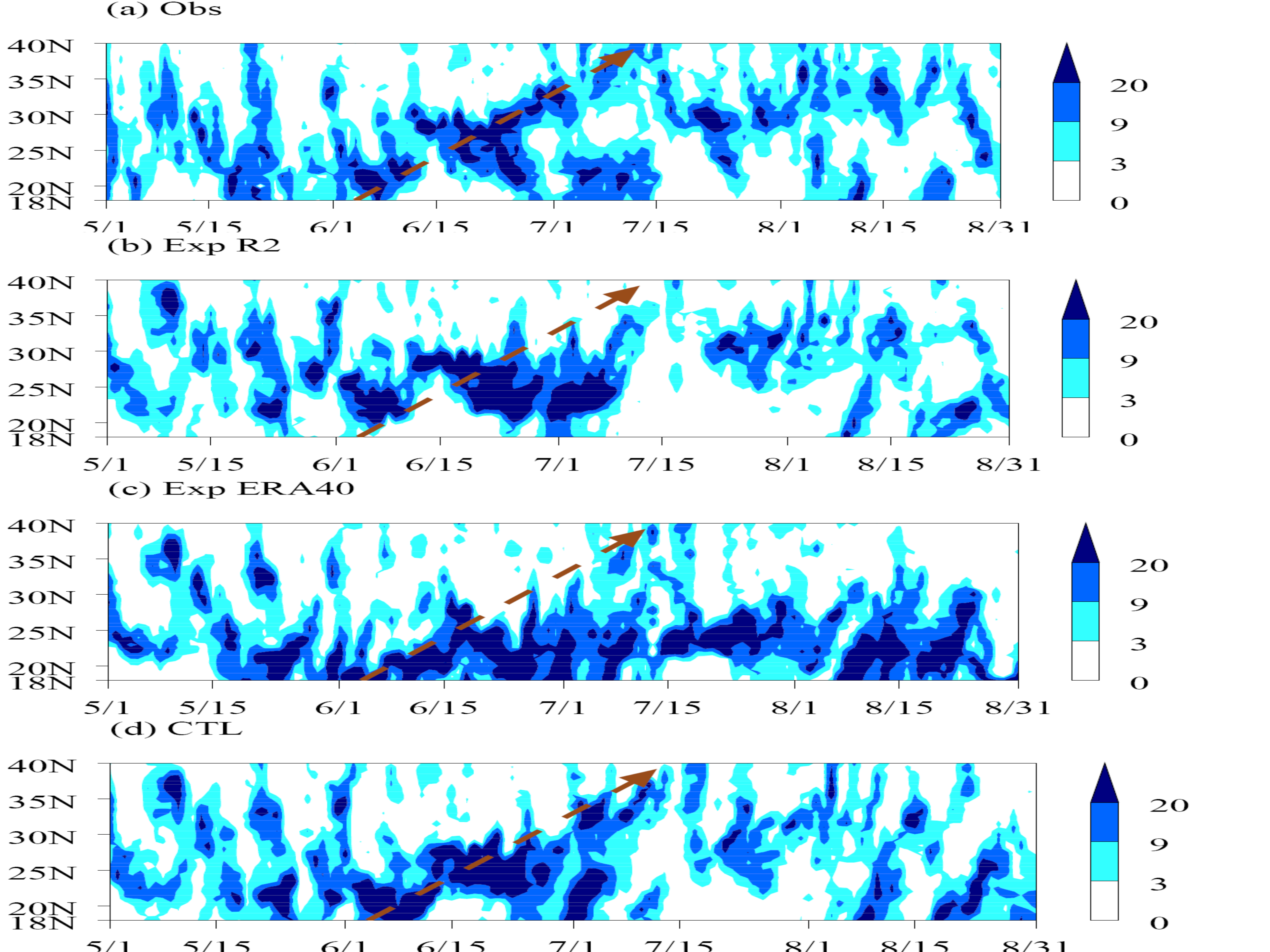
- How do the uncertainties in the large scale forcing fields give rise to the RCM errors?
- Can we reduce the impacts of those uncertainties?
- How does the boundary buffer zone affect the hydrological cycle and water vapor budget in the regional climate simulation?
- Can a RCM correct precipitation biases in the large scale driving field?

JJA mean low-level circulation and model biases



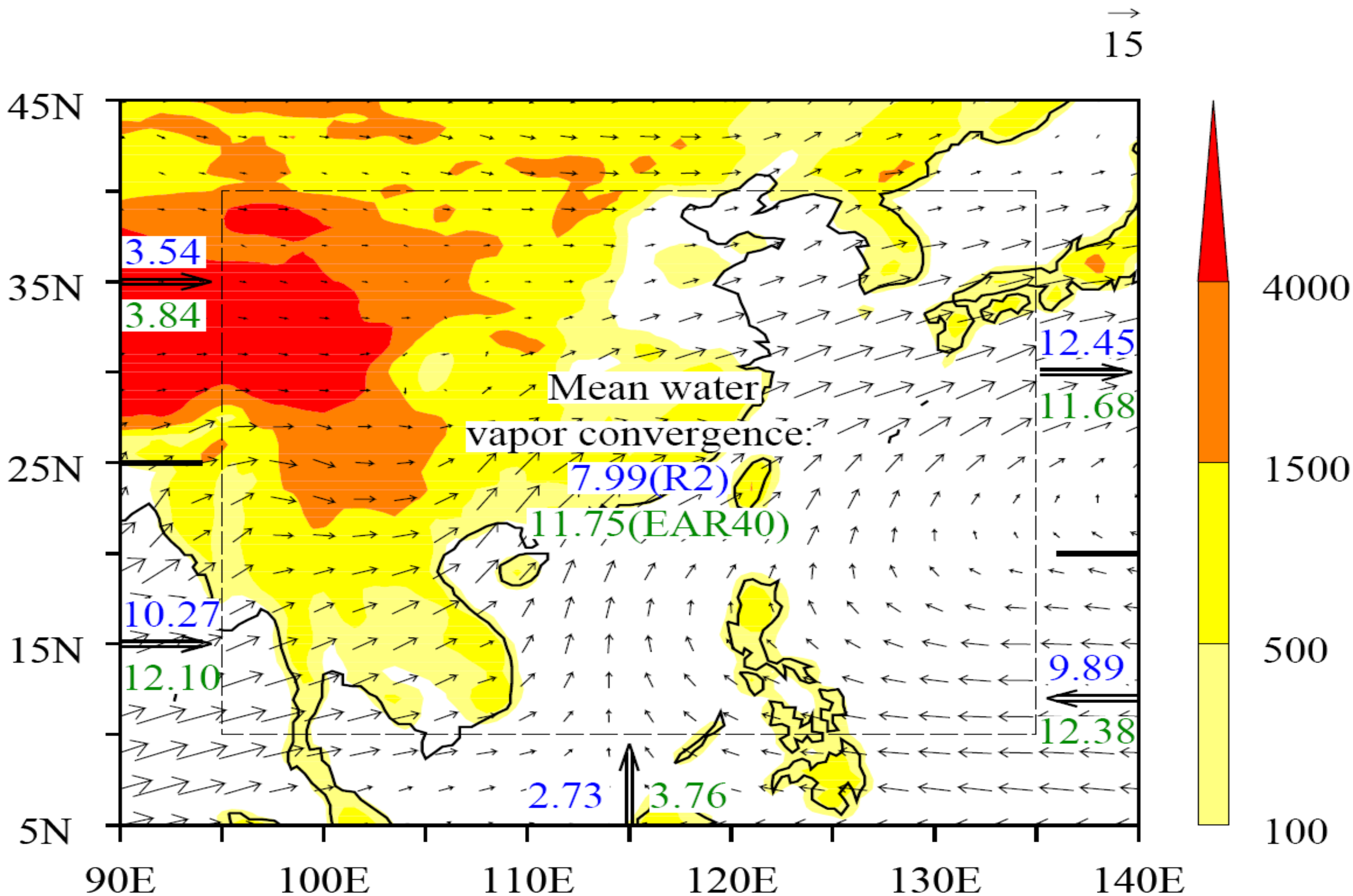
Model domain and topography





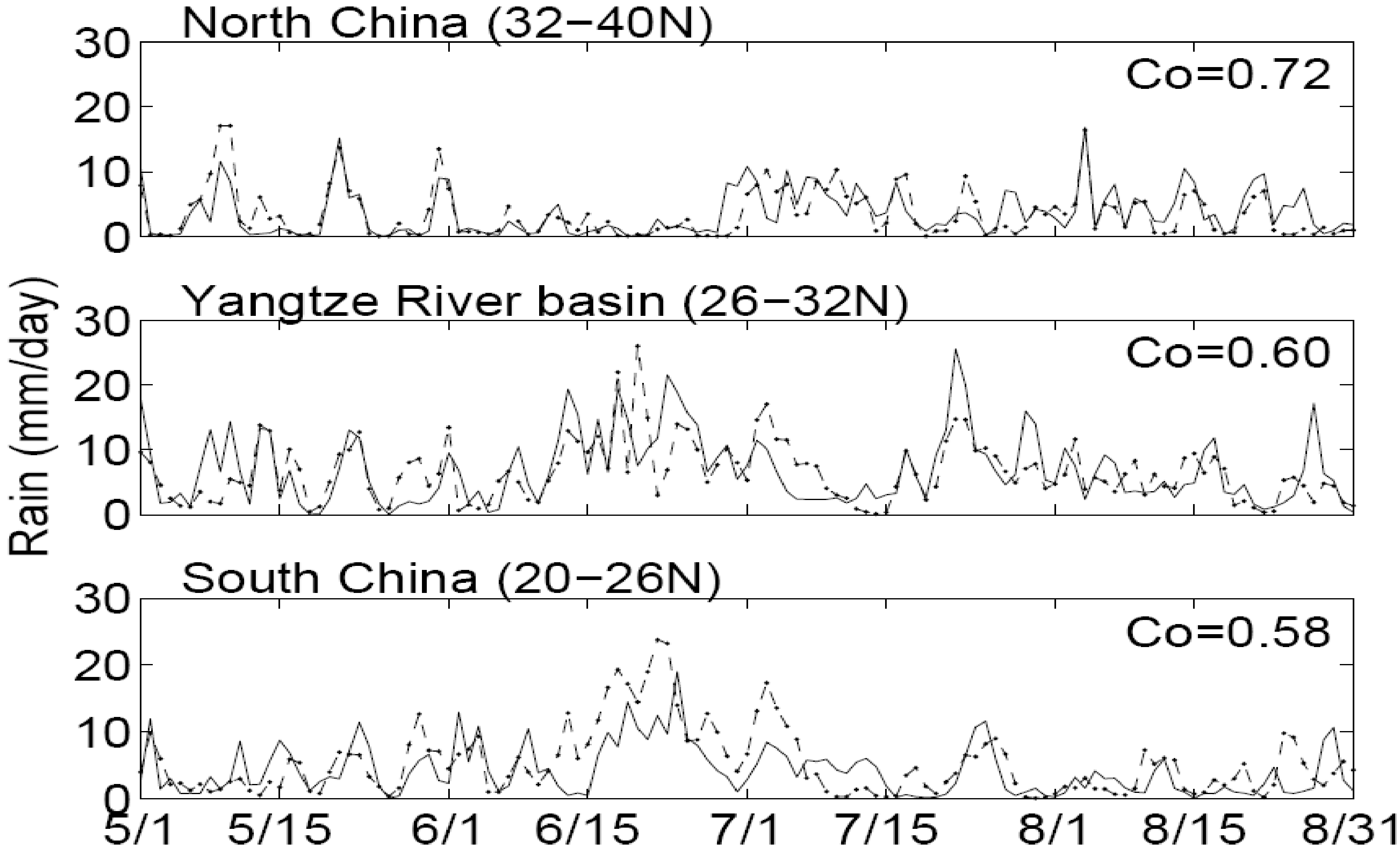
(a) Obs
(b) Exp R2
(c) Exp ERA40
(d) CTL
40N
35N
30N
25N
20N
18N
5/1
5/15
6/1
6/15
7/1
7/15
8/1
8/15
8/31
20
9
3
0

Vertically integrated water vapor inlux and convergence



Blue: NCEP/DOE R2   Green: EAR40

Daily precipitation rate (105E-122E)

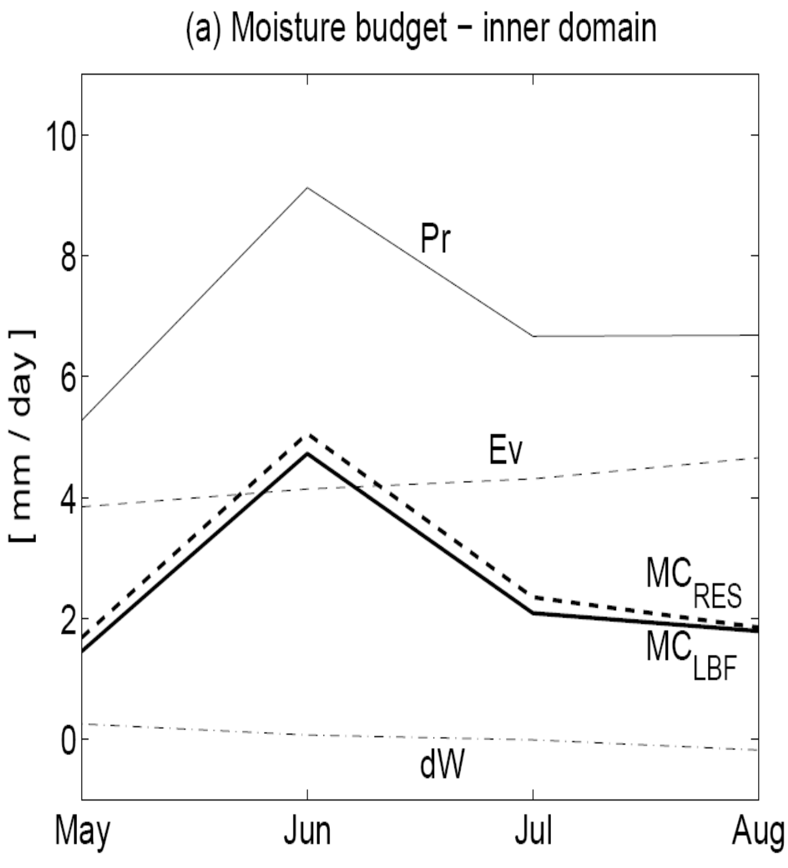


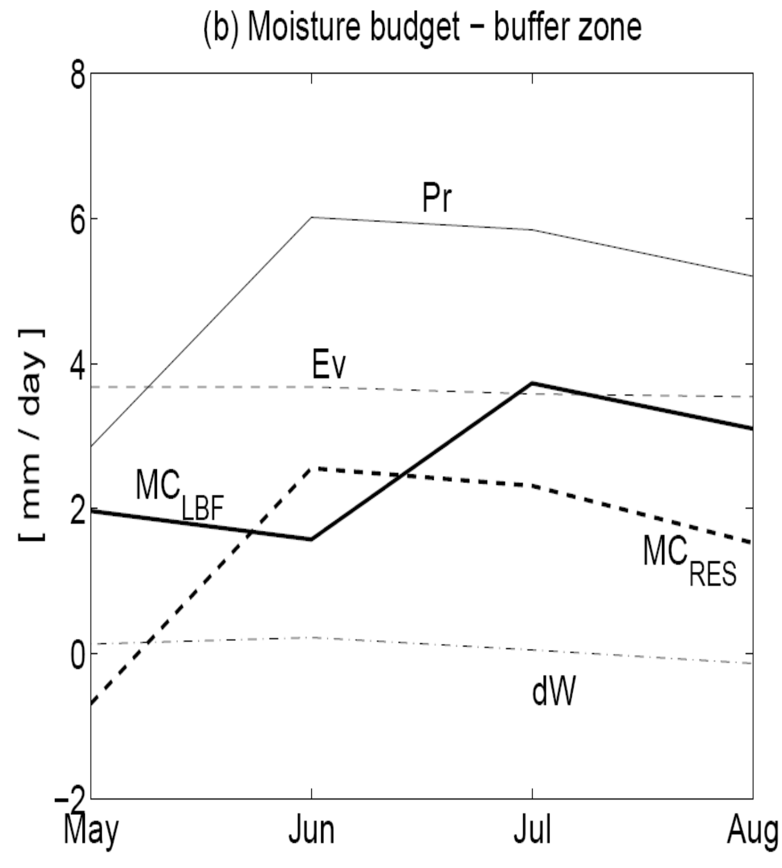
Solid: Observation   Dashed: CTL simulation

Moisture Budget

$MC = Pr - Ev + dW$

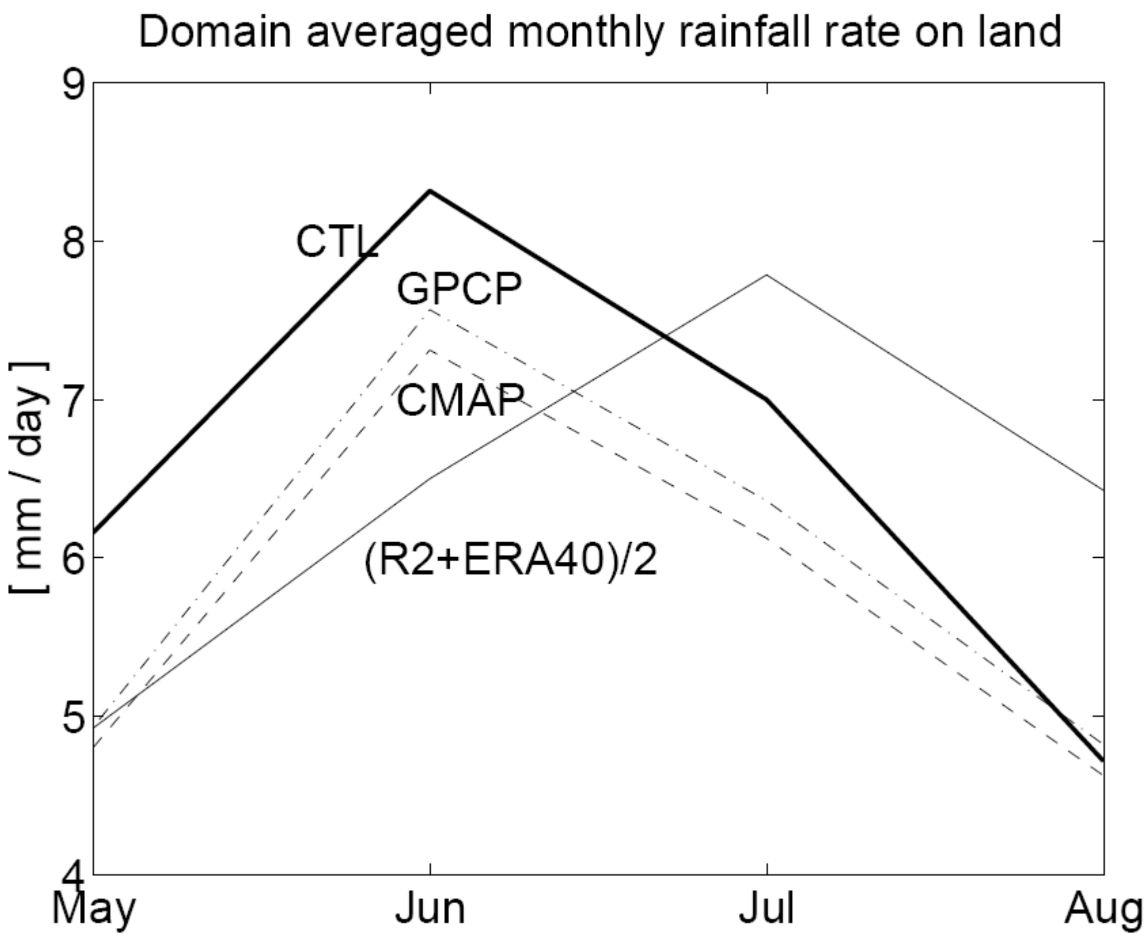
$$\frac{\partial W}{\partial t} + \nabla \bullet Q = E - P,$$





Water vapor odes not conserved in the buffer zone

Validation of precipitation in Eastern China (20-40N, 105-122E)



RCM simulation correct biases in the large scale forcing field

Conclusion

- With the driving fields from NCEP/DOE R2 and ERA40, the WRF model simulations with the same model configuration yielded remarkable differences. These differences are primarily caused by the uncertainties in the water vapor influx across the lateral boundaries.
- The summer-mean water vapor convergence into the model domain computed from the ERA40 is 47% higher than that from the R2.
- The largest uncertainties in moisture transport are found from the Philippine Sea and the Bay of Bengal.
- The biases induced by the boundary conditions can be reduced by using an “ensemble” mean lateral boundary forcing.
- The buffer zone fails to conserve moisture.
- The WRF regional model simulation was able to correct the precipitation biases in the large scale driving field.